1750 METERS: WESTERN UPDATE #58

THE WESTERN NEWSLETTER FOR THE EXPERIMENTER'S BAND (160 TO 190 KHz)

Available for business-size 25 cent SASE's, plus 60 cents per issue (or $7 per year)
from: Jim Ericson, 226 Charles St., Sunnyvale, CA 94086

ACTIVE WESTERN LowFER BEACON STATUS (LIST COMPILED August 18, 1988)

FREQ(kHz)	IDENT	QTH	SKED INFO
162.35a	XU	San Ysidro, CA	24h/7d. New Beacon.
163.80	FPV	Granada Hills, CA	24h/.7d. Note QSY.
163.85	M	San Diego CA	Testing sometimes..
166.667	H	Descanso, CA	24h/7d
167.25	AHN	Fallbrook, CA	24h/7d
169.863	1SUN	Durant, OK	Off till September
175.225	MAX	Wheatland, WY	24h/7d CW. BPSK/ASCII by request.
175.703	FAW	Orem, UT	24h/7d
176.00	HDOMBAY	Morro Bay	24h/7d
176.26	C O	Glenwood Springs, CO	24h/7d
176.75	SR	Elgin, OR	24h/7d. New Beacon.
176.963	C	near Morro Bay, CA	24h/7d.
177.48	UCP	Saratoga, CA	Daily, approx. 1400 to 1700 UTC.
177.750	CT	Bountiful, UT	24h/7d (BPSK/CCW alternating)
178.00	AT	Crow, OR	Off until Fall
179.0	MPM	Salt Lake City, UT	24h/7d ASCII/CW alternating 5minutes.
180.601	NX	Los Altos Hills, CA	Off. Schedule unknown.
180.66	NRE	San Diego, CA	24h/7d. New Beacon.
181.17	IZJ	San Gabriel, CA	Daily. Silent 0700 to 1100 UTC.
181.287	MEL	San Jose, CA	24h/7d.
181.711	TLX	Novato, CA	24h/7d
182.672	G	Palo Alto, CA	Intermittent.
182.88	H2	Descanso, CA	24 hours Friday, Saturday, Sunday.
183.160	PRK	Saratoga, CA	24h/7d
183.63	PLI	Toluca Lake, CA	24h/7d
183.95	8 dits	Palo Alto, CA	24h/7d. New. Same QTH as "G".
184.016	EK	Sunnyvale, CA	24h/7d
184.425	V	Sunnyvale, CA	Occasional testing
185.0	ZYK	Redway, CA	24h/7d
185.100	T	Rohnert Park, CA	24h/7d At Sonoma State Univ.
185.49	AZ	Tucson, AZ	Off till September
186.80	BA	Lancaster, IL	24h/7d. Note QSY.
187.0	ELU	Simi Valley, CA	24h Sat. & Sun on SSB
187.252	TEXAS	NW of Ft. Worth, TX	24h/7d. New Beacon.
187.263	SKY	9 mi. NW of San Simeon, CA	By request. Contact Z2 or EK.
187.30	UPN	Cincinatti, OH	24h/7d
187.50	DCH	Berlin, MD	Off till September
187.47	SM	San Jose, CA	24h/7d.
190.4	OHH	Ontario, Canada	24h/7d.

LOTS MORE SASES ON FILE

(Check means sig logged at EK QTH in July/August. Double check is QSO with EK. Non-Western listings are beacons currently being copied in the West, or they have SASE's on file with us). "a" means frequency is approximate (non-crystal controlled).

EK NOTES: While most of us have been caught up in the usual busy summer activities, it doesn't seem to have slowed down progress out there in Lowfer-land! Note the number of new beacons which have come up on the air recently. Technical articles have literally swamped me (but keep 'em coming!). And BIG news from Hawaii where **Sheldon Remington** reported copying **Frank Cathell's H beacon** from San Diego on July 1st! This is the second US mainland LowFer copied in Hawaii by Sheldon. Distance = 2530 miles. The first was Z2 in San Simeon, CA. Both have a good clear shot at the Pacific Ocean.

Congratulations to **Herb Balfour (OHH)** of Ontario, Canada for publishing his flagship issue of **THE NORTHERN OBSERVER: 1750 METRES!** The format is much like that of **WU**, except the primary focus is news of Eastern, Central, and Canadian LowFER activity. The purpose of both our newsletters is to provide fast turn-around frequency listings and news. Herb and I are NOT in competition! On the contrary, we plan to cross-fertilize the newsletters with information, and share articles from time to time. Please support Herb in his new effort. Since he must use Canadian postage, his arrangement is 12 business-size self-addressed envelopes (he will affix Canadian stamps), plus ten dollars in US funds (US checks are OK). Herb's Ontario address is in the listing of this issue. Good Luck Herb!

MAILBAG: **Greg Raven** writes to inform everyone that "a new beacon with the call letters **TEXAS** has been activated. It is located slightly NW of Fort Worth, near a town called Haslet at the QTH of **Bill WD5CVG**. The frequency is 187.252 kHz. The antenna is a 42 foot steel TV mast with an 8 foot diameter tophat. The ground system consists of 12 radial #14 gauge copper wires. The transmitter is class E type that runs 80% efficiency. Measured antenna current is roughly 60 mA. The transmitter is still far from being optimized, however. I am using toroids of unknown permeability to resonate the antenna, and I have no idea of the value of the load impedance that I am presenting to the transmitter."

Steve Ratzlaff reports, "...Finally got a LowFER beacon on in Northeastern Oregon! It is **SR** on 176.750 kHz 24h./7days. I heard it from 50 miles, so its doing something. Please list it at my father's QTH (**Sid Ratzlaff KA7SKA**, Route 2, Box 56, Elgin, OR 97827) as he'll be watching over it."

Brice Anderson checked in saying summer Illinois thunderstorms have caused impossible QRN lately. Brice notes, "I last heard **WI** on July 3rd. I last heard **TH** on July 7th. I hear **UPN** often. Also, I have changed my beacon (**BA**) frequency to 186.80 kHz to get away from a bothersome power line carrier. Still on 24h/7days when weather permits."

Arliss Thompson (AT) writes, "I haven't much LowFER news. However, I'm looking forward to this fall and winter when I'll be able to do some listening from my new location. Being on a small (40 acre) farm some distance from town, I anticipate conditions here will be far superior to those I experienced in Portland. **AT** is off the air for now. It made the trip with us to South Dakota and will be on the air this fall, with no change in frequency."

Bob Cutter(CO) writes from Colorado, "...One of my most perplexing information problems has to do with coils. I mean size, variometer designs, turns, wire type, etc. If people want to send me related info from their files, I would be happy to compile it."

If you think YOU'VE been busy lately, listen to this report from **Dave Raney of Ohio:** "Wind took down my LF vertical. PVC base snapped. Nylon guy rope failed. Put antenna back up, then two tophat suspension cords failed. Got those back up and, although its a bit droopy now, it tunes up fine. We gotta be nuts to keep this up! (Isn't that a requirement?). My top-loading coil, located just under the 15-foot radius tophat, has allowed me to reduce the base loading coil inductance somewhat. I now need NO ferrite to resonate. Current tophat is six radial wires with a skirt wire. I will add two more skirt wires to reduce tophat resistance. From past experience, that's about the point of diminishing returns for increasing capacitance and lowering the resistance of the 'capacitor' charge circuit. This will also mean adding an increment of top loading inductance, comparing current-up-the-mast, and Brice Anderson's signal reports out at 190 miles. We'll see what happens." Dave also notes that his new ham call is **WC8E**, and also that his LF beacon ident may change to **WCAT** or maybe **CAT.**

Rick Wright (1SUN) hasn't exactly been goofing off, either. He says, "This has been a GOOD summer for building circuits. I have been exploring 'front-end amplitude limiters' -- a type of RF processor, if you will. It is evident that **Mike Mideke** has formed some similar ideas, but I don't know if he has tried constructing actual circuits. I plan to send you detailed diagrams of working circuits by mid-September, but I want to tie a few loose ends together before I make that report. ...The dynamic range of impulse noise is so great that its presence is absolutely anathema to the narrow-band receiving methods that we believe in. I'm saying that the situation can be made much better if we face up to this problem by introducing limiting in the time domain (i.e., amplitude limiting). Also, the amplitude limiter has to occur FIRST in the signal path." **Rick adds that he could use a 50 to 100 microsecond delay line for this project. Any suggestion for a cheap source?**

On page 2 of WU#57 we published an article on LowFER transmitter efficiency, written by **Cliff Buttschardt.** Cliff's intent was to stir up some good technical debate on the subject, and it seems to have worked! Mark Mallory (**MPM**) writes, "I'm working on an article describing my 'high-efficiencyt' transmitter. Should be sending it in a week or two. By the way, MPM still on the air...same format as always." On the same subject, **Clint Turner** of Utah comments,"I read Cliff's article with interest and skepticism. I think (and **Mark Mallory** agrees) that the statement 'In general, if fifty percent DC-in to RF-out efficiency can be gotten, the design is good...' is a bit, well, strange. The article is unclear...as to how efficiency is to be measured, but even at the extreme, I beg to differ that 50% is good. It is terrible! From the output (not including loading coil) one should expect over 65% efficiency from even a sloppily designed class-C amplifier, and over 75% is very easily attainable." Clint sent along much additional information, including a design that he indicates can attain over 80% efficiency. Unfortunately, we're flat out of space in this issue, so we'll hold it for later. Don't miss Frank Cathell's article on the efficiency subject in this issue.

Well, that's about it for this edition. Thanks for all the inputs, and keep 'em coming! Also, another reminder about SASE's. We drop 3 or 4 people a month from the mailing because they have run out of SASE's. We do this REGARDLESS OF HOW MANY $'s HAVE BEEN DONATED! The reason is not that I'm a bad guy, but I simply don't have the time to get into the stamp and envelope business (and keeping track of the $). Please understand this procedure and keep your SASE's current. 73 from Jim Ericson.

Jim

An Analysis of the LowFER Transmitter Circuit

by Frank Cathell (K3YAZ, H, H2)

After reading Cliff Buttschardt's preliminary article on LowFER transmitter efficiency (WU #57) and seeing the many comments, improvements, etc. concerning the "simple beacon transmitter" circuit first presented by Mike Mideke in WU #53, I felt that a proper circuit analysis may help in the further understanding of this circuit as an efficient yet simple LowFER transmitter. The operational description will be referenced to Jim Ericson's Revision 1 of the circuit in WU #57.

Several other representative LowFER transmitter designs were studied and it appears that the power mosfet amplifier stage represented in the "simple beacon" circuit is the one most commonly used. Contrary to popular belief, the amplifier is NOT a true class C type output stage. The power mosfet operates as a saturated switch in the class F mode. The standard class C amplifier can achieve high efficiencies, however, maximum efficiency and maximum power cannot normally be produced simultaneously. In contrast the class F radio frequency amplifier can theoretically achieve 100% efficiency at maximum power. Practical efficiencies, however, are typically in the high 80 to 90% range.

For ideal operation the gate should be driven with a 50% duty cycle square wave with fast rise and fall times. During the time the mosfet is on the drain to source voltage (Vds ON) should be very low (< 1 volt) assuming proper mosfet selection and gate voltage. During this period the current through the device has two components; the part through broadband tank inductor L1 which is storing energy in its magnetic field, and the current from the negative half-cycle sine wave resulting from the antenna capacitance/loading coil resonant circuit. The corresponding waveforms are shown in Figure 1 below.

When the mosfet switches off, the drain voltage rises in a sinusoidal fashion due to the "flyback" energy stored in the L1/C6 resonant tank. The Vds peak amplitude will be at least twice Vin and generally higher if the Q of L1 is high. This half-cycle sine wave component drives the antenna/loading coil resonant circuit which will complete the remainder of the sine wave when the mosfet switches back on. The coupling to the antenna/loading coil circuit can be either capacitive (as done with C7 in Jim's schematic) or inductively as done in the Palomar transmitter circuit. Both techniques will work well, however, the harmonic attenuation is better in the inductively coupled case.

The interesting part about the class F amplifier is that the mosfet operates as a saturated switch and because the voltage and current waveforms through the device are sinusoidal and 180 degrees out of phase (see waveforms below), there is never simultaneous voltage and current on the device. The only dissipation is caused by the on resistance of the mosfet transistor. Properly designed, this type of rf amplifier can achieve efficiencies that cannot be matched with conventional class C or most class B or AB type amplifiers.

Maximum efficiency can be generally obtained by careful consideration of two aspects of the circuit, the integrity of the gate drive waveform and the impedance matching of the mosfet drain Z to the antenna circuit Z.

Again, contrary to popular belief, the gate drive to the mosfet should be a 50% duty cycle square wave with fast rise and fall times (the 25% or 120 degree type drive often quoted is for class C amplifiers or frequency doubling stages). The problem with most LowFER transmitter designs is that the mosfet is driven directly from the high impedance output of the CMOS oscillator or divider IC. This direct coupling will distort the drive waveform, especially the rise and fall times, as a result of the mosfet's gate and Miller capacitances being driven from a high Z source. This ultimately results in a drive waveform exceeding 50%. As a consequence the half-sine wave drain voltage produced when the mosfet switches off never has time to fully complete (go to zero) before the transistor turns on again (see Figure 2). This results in a slicing off of the trailing edge of the sine wave and simultaneous current and voltage occuring momentarily in the device (e.g. switching losses). This distortion will have minimal effect on the output harmonics because the high Q of the antenna circuit will maintain a good output sine wave, but the dissipation in mosfet will seriously affect the system efficiency and increase the dc input current to the amplifier stage.

A solution to this problem is to insert a gate driver/buffer stage between the divider/oscillator chip and the mosfet that can adequately drive the gate capacitance during turn-on and turn-off. This could be a line driver type IC or a simple complementary npn/pnp transistor driver as shown in Figure 3. Care should also be taken in determining the state of the output of the divide-by (counter) IC used when the reset is in the high (stop counting) state. The chip's output may go high (as in the 4024) resulting in the mosfet being left in the on state and burning up. Either capacitive gate coupling or an inverting buffer/driver stage will be necessary here.

The other factor influencing efficiency is the impedance matching of the mosfet drain to the antenna circuit. The output impedance Zo of a 50% duty cycle driven class F stage is given by:

$$Z_{OUT} = \frac{V_{in}^2}{2 P_{in}}$$, WHERE P_{IN} IS THE INPUT POWER TO MOSFET

Substituting values for a typical LowFER transmitter with 12 volts Vin and 1 watt input gives:

$$Z_{OUT} = \frac{(12)^2}{2 \times (1W)} = \frac{144}{2} = 72 \text{ OHMS}$$

If the antenna circuit shows exactly 72 ohms when in resonance the match is perfect. This value and ones close to it are fairly representative of a typical LowFER antennas and the antenna circuit can be connected directly in most cases. Values much lower or higher will require a matching circuit between C7 and the antenna loading coil. A properly designed pi-network would certainly be the one of choice here. In the case of the Palomar transmitter type inductive coupling the link turns need to be of the proper number.

In summary the maximum efficiency of the class F LowFER transmitter will be obtained when the mosfet amplifier is driven with a 50% duty cycle square wave with fast rise and fall times and the amplifier's output impedance is properly matched to the antenna. Mike's "simple transmitter" with the proper modifications, may be closer to being the ideal LowFER transmitter than previously imagined!

FIG 1: IDEAL WAVEFORMS

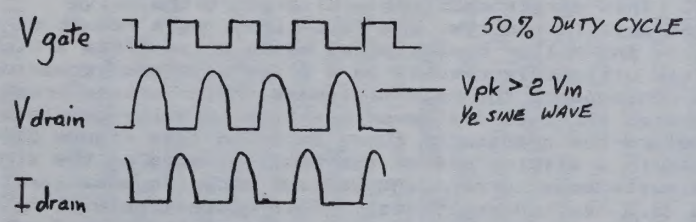


FIG 2:

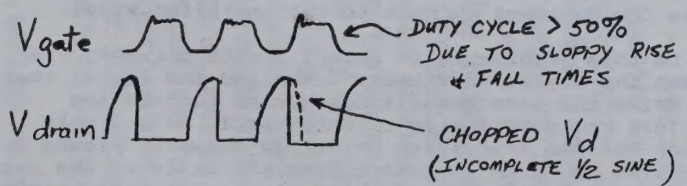
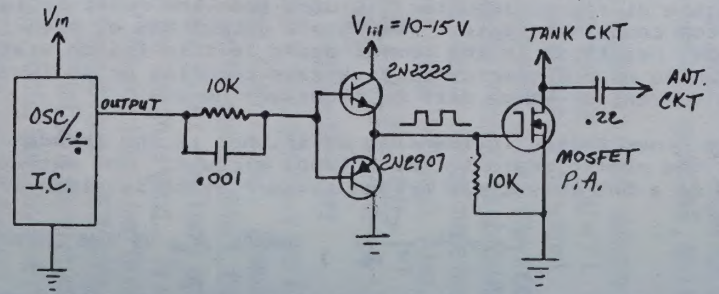
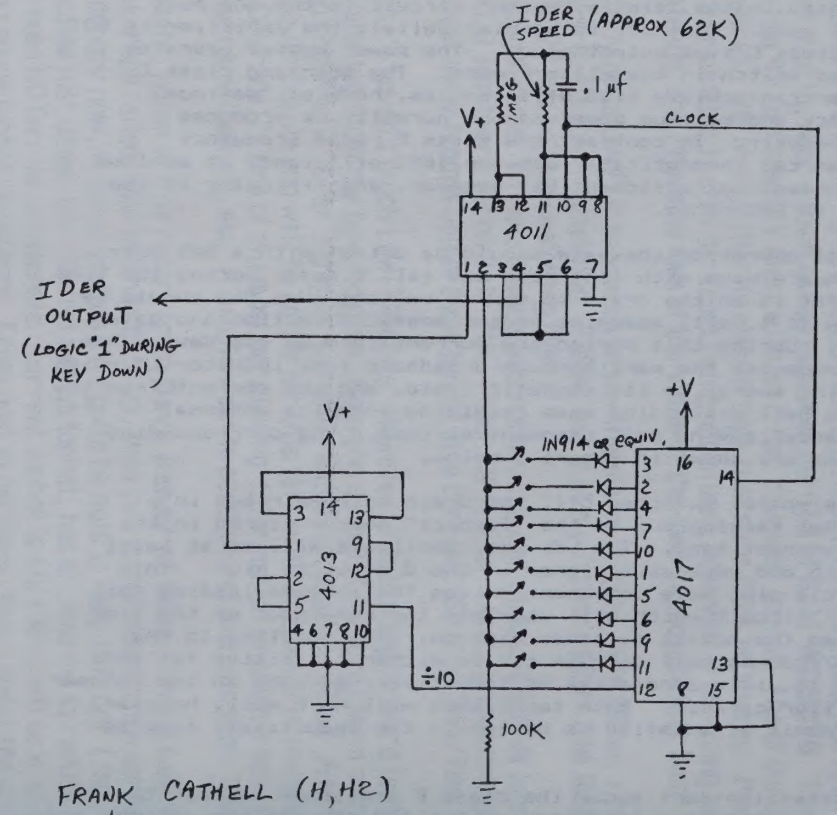


FIG 3: COMPLEMENTARY DRIVER/BUFFER



Improved Simple IDer Circuit

Shown below is an improved version of the Mike Mideke simple IDer circuit shown in WU #53 for a 1750M beacon. A 4013 CMOS "D" type dual flip-flop has been added which divides the last output of the 4017 by 4. The 4013 output is then ANDed with the 4017 output in the 4011. This results in the IDer being able to send double letters (RR, KK, AA, etc.) with a reasonable space between the character sets. With the proper selection of diodes the circuit will also send a limited number of three letter IDs such as EDN, TUI, ERA, TMT, and several more due to the run-on characteristic when the 4013 repeats the output sequence of the 4017 the second time before the space is sent.



FRANK CATHELL (H,H2)
6/88

VLF CONVERTER

Build this 10 MHz up-converter if you are interested in receiving signals from time standard, FAX, RTTY and other utility stations operating in the kilometric bands.

Thanks to Frank Reid for this reprint from Elektor Electronics Magazine (Europe) , May 1988. Next issue we will publish another NE602 converter design by Frank Cathell. (ed.)

The frequency range from 30 kHz to 150 kHz is generally referred to as the Very Low Frequency (VLF) band. It is used relatively little, because high transmitter powers and large aerial systems are required, which generally give a relatively small coverage (typically about 300 to 1000 km). For a number of applications, this is not considered a disadvantage, however. Propagation of VLF waves is highly predictable, since there is virtually no atmospheric reflection: the transmitter range is, therefore, fairly accurately defined. VLF signals travel almost exclusively via the so-called *ground wave*, while the ground-ionosphere space acts as a waveguide. Thanks to this property of the VLF band, received signals are usually free from phase shift and amplitude variation (fading), so often found on the shortwave bands. The VLF band is well suited to medium-range, one-way data communication, such as time standard transmitters (Rugby GBR, Rugby MSF, Mainflingen DCF77, Prangins HBG), meteorological facsimile, submarine communication, and telex networks. One disadvantage of the VLF band is the huge aerial system required at the transmitter side. Aerial systems of several square kilometres, and with multiple transmitter feed points, are not uncommon, yet attain a radiation efficiency of only a few percent. At the receiver side, due account should be taken of the high level of man-made noise (computers, neon tubes, TV sets and other electrical appliances). In most cases, the so-called *long wire* is the only feasible aerial at the receiver side. Thirty metres or more of sloping or horizontally running insulated wire, mounted well away from the previously mentioned sources of interference, is recommended for serious experiments in receiving VLF transmissions.

Generally, the lower the frequency, the rarer and more interesting the stations. Not every communications receiver can be tuned as low as 15 kHz, but this is made possible by the up-converter described here. It effectively converts the frequency range from about 15 kHz...300 kHz to 10 MHz, so that the CW, RTTY, FAX, AM or SSB facilities of the communication receiver tuned between 10.000 and 10.300 MHz can be exploited to receive VLF transmissions.

Circuit description

The VLF converter is an application of the Type NE602 active double balanced mixer and oscillator, whose block diagram is shown in Fig. 1. The chip requires only a handful of external components to make a good-quality up-converter.

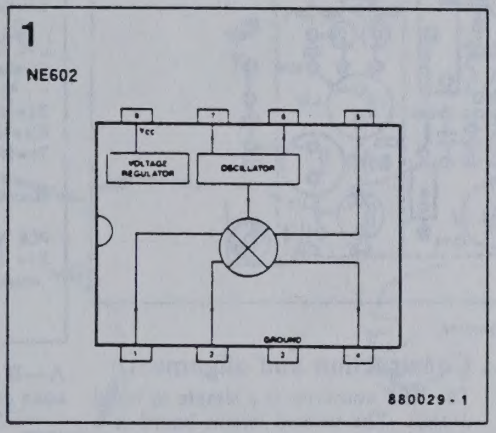


Fig. 1. NE602 integrated active double-balanced mixer/oscillator.

The circuit diagram of the converter is given in Fig. 2. The function of the circuit is to convert the frequency range from 15 kHz to about 300 kHz to an equally large band starting at 10 MHz. The SSB/CW/FAX/RTTY receiver connected to the output of the converter is tuned between 10.015 and 10.300 MHz. A VLF station such as Rugby MSF is, for example, "received" at 10.060 MHz. The VLF aerial signal is passed through low-pass filter L_1-C_2-L_2-C_3-L_3-C_4 that defines the input frequency range (15 kHz...300 kHz). Transistor T_1 forms an impedance transformer between the filter output and one RF input of the active mixer in IC_1. The NE602 is set up in an asymmetrical configuration here. RF input pin 2 is bypassed to ground with C_7, while P_1 is used for setting equal direct voltages at the RF inputs to optimize mixer balance. The output frequency of the local oscillator on board the NE602 is set to 10 MHz with the aid of an external quartz crystal, X_1. Trimmer C_{11} provides a means for accurately setting the LO frequency to 10.000 MHz, so that the tuning scale on the receiver corresponds to the true received frequency, ignoring, of course, the "10" preceding the kHz digits in the read-out.

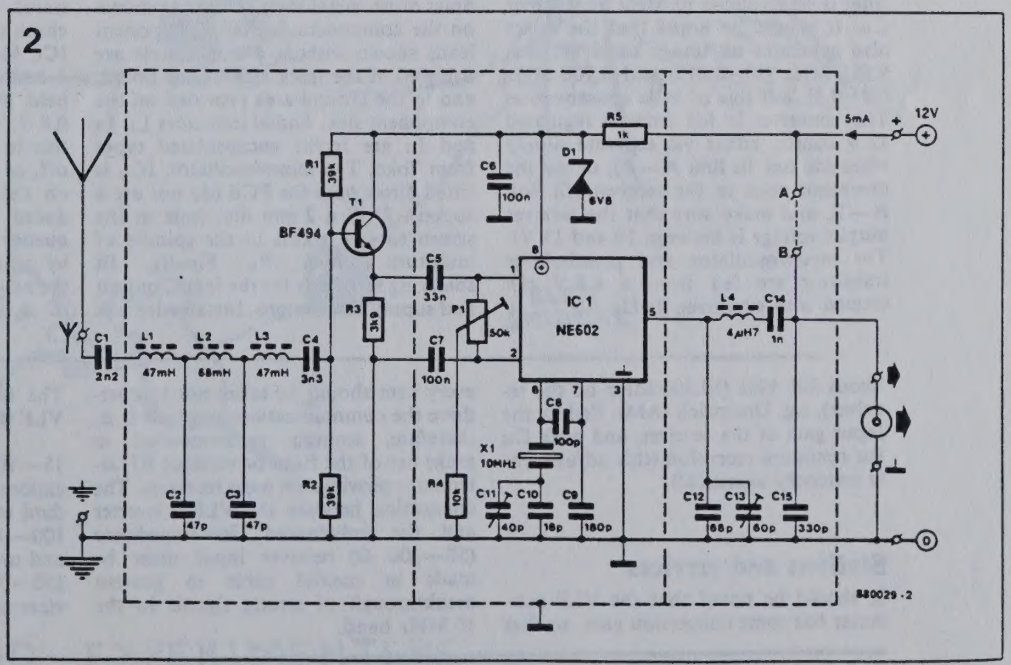


Fig. 2. Circuit diagram of the VLF up-converter.

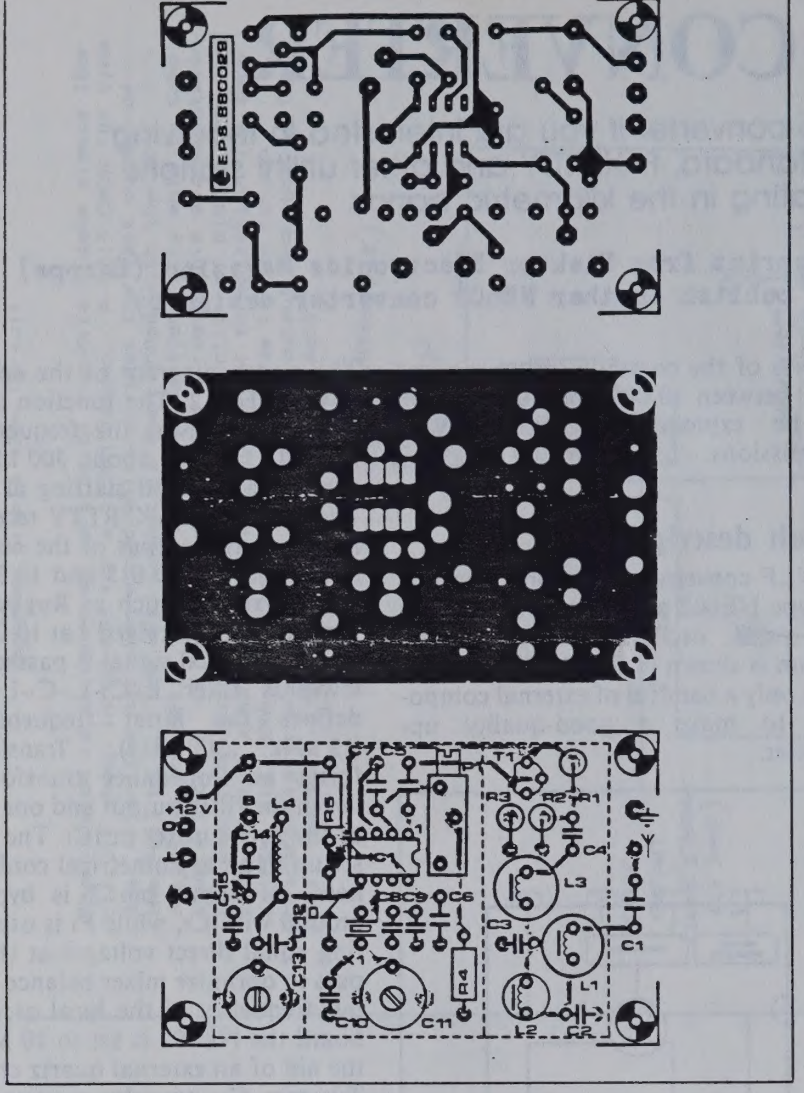


Fig. 3. Printed circuit board for the VLF converter.

Parts list

Resistors (± 5%):

R1;R2 = 39K
R3 = 3K9
R4 = 10K
R5 = 1K0
P1 = 50K multiturn preset

Capacitors:

C1 = 2n2
C2;C3 = 47p
C4 = 3n3
C5 = 33n
C6;C7 = 100n
C8 = 100p
C9 = 180p
C10 = 18p
C11 = 40p trimmer
C12 = 68p
C13 = 60p trimmer
C14 = 1n0
C15 = 330p

Inductors:

L1;L3 = 47mH ferrite encapsulated choke for radial mounting: Toko Type 181LY-473 (Cirkit stock no. 34-47302).
L2 = 68mH ferrite encapsulated choke for radial mounting: Toko Type 181LY-683 (Cirkit stock no. 34-68302).
L4 = 4μH7 axial choke.

Semiconductors:

D1 = zenerdiode 6V8; 400 mW
IC1 = NE602 (available from CSI Electronics)
T1 = BF494 (Maplin order no. QQ19V)

Miscellaneous:

PCB Type 880029 (see Readers Services page).
X1 = 10 MHz quartz crystal; 30p parallel resonant.

The output of the active double balanced mixer is a single-ended configuration. The up-converted frequency band is filtered in pi-section $C_{12}+C_{13}$-L_4-C_{14}-C_{15} to suppress spurious mixer products. The low-frequency roll-off point of the filter is set to about 10 MHz by trimmer C_{13}. It should be noted that the mixer also generates an image band between 9.985 MHz (10−0.015) and 9.700 MHz (10−0.3), but this of little consequence. The converter is fed from a regulated 12 V source, either via separate supply wires (do not fit link A—B), or via the downlead coax to the receiver (fit link A—B, and make sure that the receiver output voltage is between 10 and 15 V). The mixer/oscillator and preamplifier transistor are fed from a 6.8 V rail created with stabilizer R_5-D_1.

Construction and alignment

The VLF converter is a simple to build project. The printed circuit board is a double-sided, but not through-plated, pretinned type—see Fig. 3. Commence the construction with fitting 15 mm high brass or tin metal sheet screens as shown on the component overlay. Component leads shown without a small circle are soldered at the track side of the board, and to the ground area provided on the component side. Radial inductors L_1, L_2 and L_3 are ferrite encapsulated types from Toko. The mixer/oscillator, IC_1, is fitted direct onto the PCB (do not use a socket). Drill a 2 mm dia. hole in the screen to give access to the spindle of multiturn preset P_1. Finally, fit soldering terminals for the input, output and supply connections. Install wire link A—B if the converter is powered via the coax cable to the receiver.

Set P_1, C_{11} and C_{13} to the centre of their travel. Apply 12 V to the circuit, and check the presence of 6.8 V on pin 8 of IC_1. Measure the direct voltage on pins 1 and 2, and adjust P_1 until both are held at an equal potential of about 0.8 V. Connect the receiver, and tune this to 10.000 MHz. Mode: CW, BFO off, or to the centre of its travel. Switch on the input attenuator, or select reduced RF input gain. Lower the frequency of the beat note heard to nought by adjusting C_{11} (zero beat). Connect the aerial to the VLF converter, and tune to a relatively strong transmission at about 200 kHz (10.200 MHz on the receiver), e.g. Droitwich (AM). Reduce the input gain of the receiver, and peak C_{13} for optimum reception (this adjustment is relatively uncritical).

Stations and services

It should be noted that the VLF converter has some conversion gain, so that every care should be taken not to overdrive the communications receiver. It is, therefore, strongly recommended to make use of the fixed or variable RF attenuator provided on most receivers. The connection between the VLF converter and the unbalanced, low-impedance (50—100 Ω) receiver input must be made in coaxial cable to prevent breakthrough of strong signals in the 10 MHz band.

The frequency assignment used in the VLF band is roughly as follows:

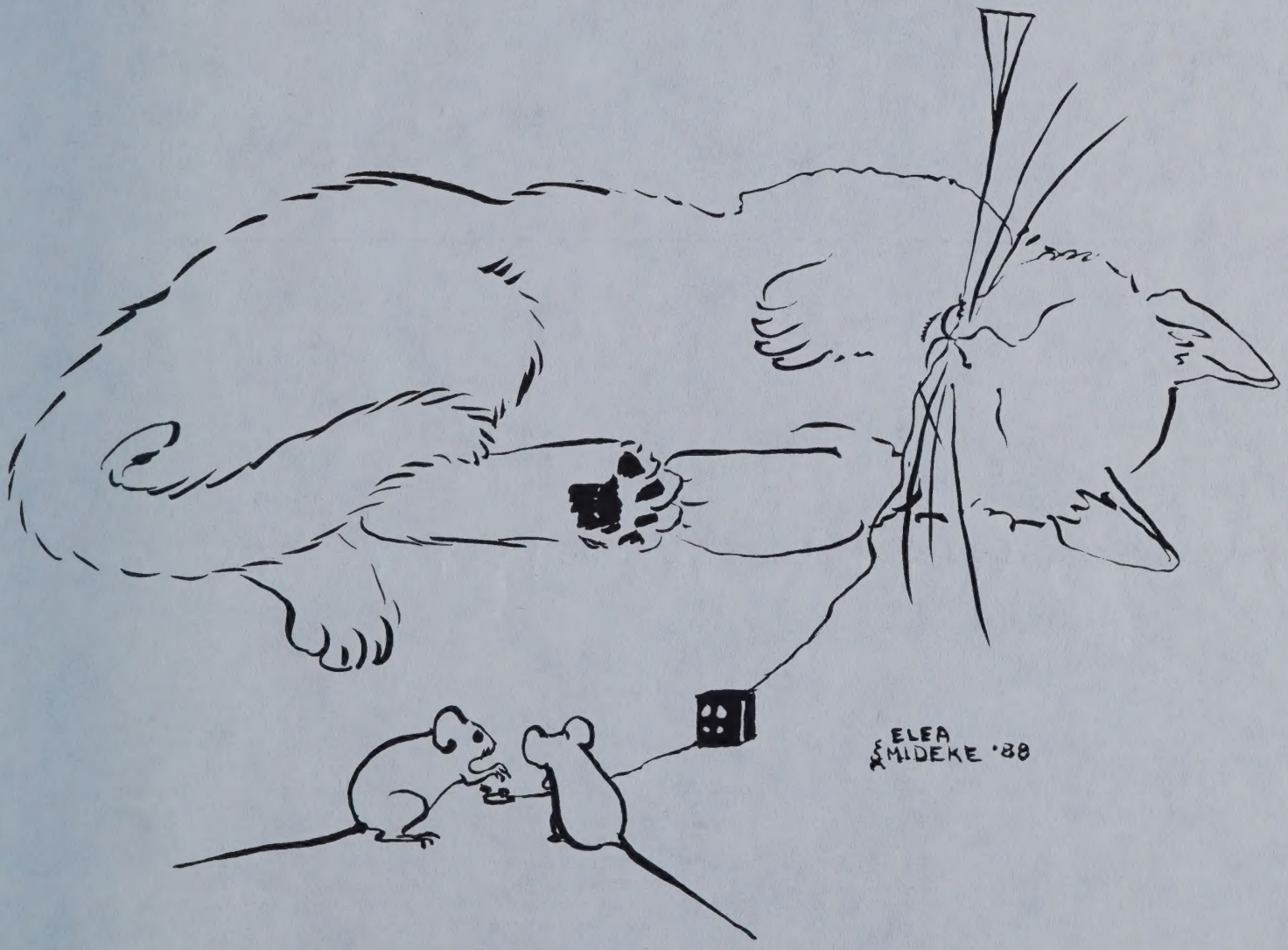
15—100 kHz: submarine communications (CW), beacons and time standard transmitters;
100—150 kHz: RTTY (radio teletype), and meteorological facsimile services;
150—300 kHz: long-wave broadcast services and, occasionally, RTTY.

Z2 NEWS FOR WU*58 - August 15, 1988: by Mike Mideke: On August 2nd I finally got up to Z2 and dropped the antenna. All the guys and insulators have now been salvaged. That brought enough of the mess down the mountain to provide materials for the new **SKY** installation. There is no way to tell when time will become available to put up the new antenna, but at least all of the parts are on hand.

I am still hearing most of the California LowFERS during days, but most of my DX-in has been NDB's and "whistlers".

73 - mike

FOR SALE: AN/BRR-3 ITT receiver: $350; VLF synthesized signal/noise generator: $250; huge longwave literature collection, including 20 receiver manuals: $250. Will ship only literature. SASE for complete list. Hal Layer, N6SPD, P.O. Box 27676, San Francisco, CA 94127



INTREPID EXPERIMENTERS

Thanks to Dave Johnson of Los Banos, CA for these articles

A brief comparison of

1750 METER BAND ANTENNA TYPES

David E. Johnson
Fisher Research Lab

One of the subjects of constant debate among the Lowfer community is the relative merit of different antenna types--particularly vertical monopoles, top hat loaded verticals, and horizontal axis loops. I would like to jump into this fracas, stick my opinion out, and see if anybody shoots it down.

Let us compare three Part 15 transmitter antennas, each of which has been scaled for a radiation resistance of 30 millohms at 175 kHz.

1. Vertical 15 meter monopole. C=150 pF X_C=6.1K
2. Shorter top hatter, 8-12 meters tall.
   C=200-500 pF depending on dimensions. X_C=2K to 5K
3. 7.5 meter diameter loop, 65 turns. L=78 mH X_L=86K

DISCUSSION Series resonant feedpoint resistance of E-field antennas varies from about 10 ohms with a good radial system in good soil, to 100 ohms or more in shallow low-conductivity soil, especially if the radial system is not very good or there are nearby obstructions such as trees. The advantage of the top hat antenna is that its Q is lower for a given radiation resistance and feedpoint resistance. A vertical 15 meter monopole with a feedpoint resistance (of 10Ω) has a Q of 610-- a bit tweaky!

The loop illustrated isn't practical. You need fewer turns to actually build it. However, radiation resistance and inductive reactance decrease in proportion, so conclusions involving Q are still valid. To achieve a feedpoint resistance of 10 ohms with the loop illustrated you'd need a Q of 8,600-- clearly impossible. So-- a Part 15 transmitter loop can't possibly compete with an E-field antenna, unless circumstances preclude building even a mediocre E-field antenna. Unfortunately, those are the circumstances that many of us have-- so loops have their place in 1750 meter band work.

The foregoing conclusions apply at other frequencies as well, provided that Q is constant. It is difficult to achieve antenna circuit Q greater than several hundred regardless of frequency.

Also, for a given Q, changes in the size of antennas affects both verticals and loops the same way.

Now, let me put in a good word about loops. They are not so sensitive to site as E-field antennas are-- in most buildings, you can even install them indoors if you wish! If your antenna must be small, you can wind a loop that will have a reasonable impedance--unlike a small E-field antenna which at 175 kHz has an extremely high impedance. You can even tap the loop in order to match its impedance to your favorite transmitter circuit.

* * * * * * * * * * * * *

HOW TO PUT A LOWFER SIGNAL HALFWAY AROUND THE WORLD

Dave Johnson
Fisher Research Lab

The present state of the art in oscillator design (not including exotic stuff like rubidium clocks) allows us to produce (with careful attention to detail) transmitted signals having a bandwidth on the order of one ten-thousandth of a Hertz at 175 kHz. If the transmitted signal is going halfway around the world, variations in the ionosphere will probably spread this signal out to a bandwidth on the order of one thousandth of a Hertz. If the receiver uses a synchronous demodulator and local oscillator(s) with bandwidth less than one-thousandth of a Hertz, then total system bandwidth (transmitter, transmission path, and receiver) can be 10 to 100 thousand times narrower than the 10 to 100 Hz typical in Lowfer practice. This would theoretically yield an improvement in signal-to-noise ratio of 100 to 300 V/V, or 40 to 50 decibels. Since the bandwidths in typical use nowadays often allow reception of Lowfer signals over distances of several hundred miles (rarely, more than 1,000 miles) it should be possible to communicate halfway around the world with very narrow (but achieveable) bandwidths.

In the past I have suggested demodulating a signal in a bandwidth of several Hertz or more (i.e., running it through a high-Q audio filter) and then integrating the demodulated signal over an arbitrarily long period of time in order to achieve extremely narrow bandwidth. I now realize that this does not work with extremely weak signals. Here's why:

> Assume that the signal is keyed CW (this assumption is not necessary, but some assumption must be made in order to explain what follows). Next assume that its magnitude is 1 volt RMS and that the noise level within the audio I.F. bandwidth is also 1 volt RMS. Next assume that the amplitude demodulator is an RMS type (this facilitates computation, and the conclusions reached will apply to an averaging type demodulator though the numbers will be slightly off). Now, since the signal is uncorrelated with the noise, the voltage at the output of the demodulator will be 1.414 volts when the carrier is keyed "on", and 1.0 volts when the carrier is "off". A 1-volt input signal that would have produced 1 volt demodulated output in the absence of noise, is only producing an output signal of 0.414 volts.
>
> Now assume that the input signal is 0.1 volts RMS in the presence of 1.0 volts RMS of noise. The vector sum of these uncorrelated signals is the square root of 1 squared plus 0.1 squared, or 1.005 volts. The strength of the demodulated signal is only 1/20 that of the incoming signal. It is unlikely (considering that the noise level itself is variable) that an integrator could recover the carrier of this signal; only the modulation would be recoverable. To bring the magnitude of the modulation above the noise level will require an improvement in signal-to-noise ratio of 400 V/V (52 db) which in turn will require integration of 16,000 signal samples,where each sample is of the same duration as the modulation in the time domain and is synchronized (for instance) via WWV standard time signals.

In short, the integration technique is good for cleaning up a noisy but detectable signal: however, as the signal becomes weaker the integration time needed to recover the signal becomes unmanageable. The integration technique cannot substitute for synchronous demodulation where the objective is to pull out of the mud a signal that is buried deep in noise.